Missouri Department of Natural Resources
Water Protection Program

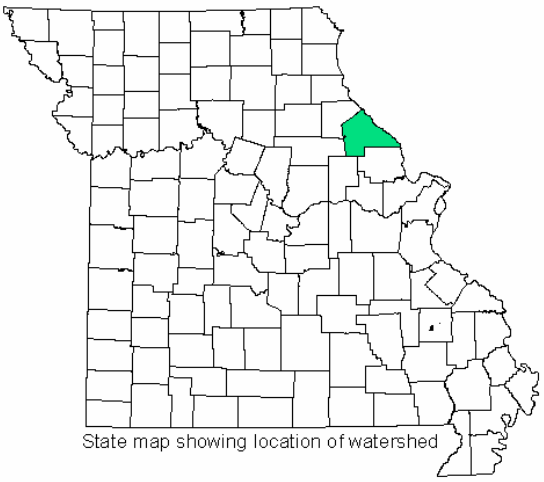
Total Maximum Daily Load (TMDL)

for
Vandalia Lake
(a.k.a. Vandalia City Reservoir or
Weldon H. "Pete" Steiner Reservoir)

Pike County, Missouri

Completed: August 9, 2006
Approved:

Total Maximum Daily Load (TMDL)
For Vandalia Lake
Pollutant: Atrazine
Phase I


State map showing location of watershed

Name: Vandalia City Reservoir (listed as Vandalia Lake in the Missouri Water Quality Standards, and known locally as Weldon H. "Pete" Steiner Reservoir)

Location: In west Pike County, Missouri, north of Highway 54 between Vandalia (in Audrain Co.) and Curryville (in Pike Co.)
(See watershed on the following Web page: www.dnr.mo.gov/env/wpp/watersheds/ws_pike.htm)

Hydrologic Unit Code (HUC-8): 07110007

Water Body Identification Number (WBID): 7032

Missouri Lake Class: L1[1]

Designated Beneficial Uses[2]:
- Livestock and wildlife watering
- Protection of aquatic life (Limited warm-water fishery)
- Human health protection (Fish consumption)
- Secondary contact recreation
- Drinking water supply

The Impaired Use: "Drinking Water Supply," found in the rules at 10 CSR 20-7.031(4)(B)4

Size of Impaired Water Body: 37 acres

Location of Impaired Segment: Sections 12 & 13, Township 53 North, Range 5 West (S12 & 13, T53N, R5W)

Pollutant: Atrazine (Chemical Abstract Service Registry Number: 1912-24-9)[3]

Pollutant Source: Corn, Sorghum Production

TMDL Priority Ranking: High

[1] Class L1 lakes are lakes used primarily for public drinking water supply. These lakes may be either public or private. See Missouri's Water Quality Standards 10 CSR 20-7.031(1)(F)
[2] The designated beneficial uses may be found at 10 CSR20-7.031 (1)(C) and Table G
[3] American Chemical Society CAS Web site: http://www.cas.org/EO/regsys.html

1. The Purpose of This "Total Maximum Daily Load"

"A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources" (See: www.epa.gov/owow/tmdl/intro.html).

The Water Quality Standards are included in the state rules administered by the Missouri Department of Natural Resources (the department). The Water Quality Standards that apply to a water body are determined by what the water is used for (that is, the designated beneficial uses). Different standards must be met for different uses (e.g., drinking water source, whole body contact recreation, industrial, etc.). A water body is considered "impaired" if the quality of the water is not considered good enough to support any one of its intended uses. In the case of Vandalia Lake, the impaired use is "drinking water supply" (See further description under "Defining the Problem" on page 4 of this TMDL).

The department's listing of impaired waters is required under Section 303(d) of the federal Clean Water Act. The department is required to develop a Total Maximum Daily Load (TMDL) for all impaired water bodies identified on the 303(d) list.

A TMDL document provides background information on the water body, a calculation of the maximum pollutant load the system can incorporate without becoming impaired (called, "assimilation"), an implementation plan to restore water quality and, in some cases, a continuous monitoring plan to evaluate the adequacy of the TMDL and its implementation. For a more detailed description of a TMDL, reference the department's fact sheet entitled, "*What are TMDLs*?" (www.dnr.mo.gov/pubs/pub2090.pdf)

2. Background and Water Quality Problems

A. Area History:

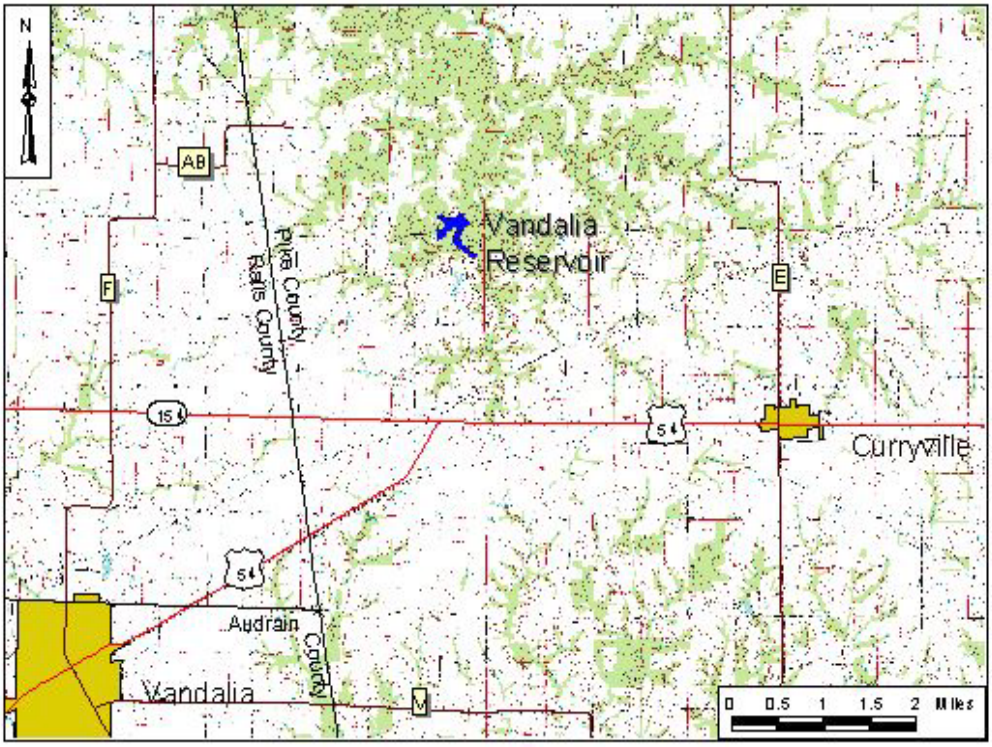
Pike County was established from a portion of St. Charles County in 1818 and was named after the explorer Zebulon Pike, of the "Pike's Peak or Bust" fame. At that time, Pike County encompassed much of northern Missouri and was sometimes called, "The State of Pike." The original boundaries of Pike County were expansive, and eventually, the area was broken up into several counties. Early agricultural products included tobacco, apples, corn, wheat and timber. Hogs and sheep were the primary livestock raised in the county. Grapes were a profitable crop, with winemaking a valuable side line. Local industry included a number of mills for grinding wheat and corn, a vinegar press, a pipe factory, tobacco warehouses, a shell button factory and a lime kiln. In 1816, James Hart Stark started his plant nursery business in the town of Louisiana. It was the first plant nursery west of the Mississippi River and went on to become the largest mail-order nursery in the world.

The discovery of gold in California affected the area profoundly. Many Pike Countians headed west for the California gold fields in 1849, and the ballads "Joe Bowers," and "Sweet Betsy from Pike" mention Pike County by name. Tales of the Gold Rush days and journals from the period depict Pike Countians as having a tough, straight-shooting and no-nonsense attitude that transferred to all Missourians out in the west (Schwadron, 1981).

An interesting review of associated Indian Tribal involvement in the area may be found at a Web site created by Lee Sultzman; www.tolatsga.org/sf.html.

Vandalia City Reservoir is located in Pike County, north of State Highway 54 between Vandalia and Curryville (See Figure 1). It was created by damming a tributary of South Spencer Creek (See watershed map at: www.dnr.mo.gov/env/wpp/watersheds/ws_pike.htm). It is a drinking water source for the town of Vandalia in Audrain County and surrounding dwellings. The reservoir was renamed Weldon H. "Pete" Steiner Reservoir on January 9, 1979, after a respected former editor of the local newspaper, *The Vandalia Leader* (Vandalia Watershed Management Committee, 1999). However, the name has yet to be officially changed with the U.S. Geological Survey (USGS). The TMDL must be titled to reference the water body listed in Missouri's 303(d) list of impaired waters, and the 303(d) list is supposed to use water body names registered with the USGS and reflected on the USGS topographic maps. Therefore, this TMDL is entitled, Vandalia Lake, as referenced in the 303(d) list. However, in order to avoid confusing this lake with another nearby water body also named Vandalia Lake (in Audrain County), the affected water body will be referenced as Vandalia City Reservoir from this point forward in this TMDL.

Figure 1. Location of Vandalia City Reservoir in Relation to the City of Vandalia.



B. Land Use and Soils:

Much of the following information was obtained from the *Vandalia Reservoir Water Resources Management Plan* (1999).

Pike County is primarily agricultural, and most of the farmland is used for crops like soybeans, corn, wheat and grain sorghum. Pasture and hayland comprise about a quarter of the acreage in the county. Hogs and beef cattle are the main livestock raised. About 25 percent of the county is forested, mostly in the northeastern part.

The annual rainfall, about 37 inches, is normally adequate for corn, soybeans, and all grain crops. Sixty percent (about 22 inches) of rain usually falls during the growing season from April to September.

The Vandalia City Reservoir watershed covers 3,655 acres. Of those acres, 1,951 are used for cropland, 728 acres are in grassland, 683 acres are wooded, 185 acres are in urban uses and 108 acres are open water (See land use map in Appendix A; MoRAP, 2000). The topography in the watershed is varied. Slopes range from zero percent to five percent on ridge tops, to five percent to 15 percent on side slopes. Slopes around the lake itself are very steep, from nine percent to 35 percent. Elevations range from 785 feet above sea level in the southwest portion of the watershed to 650 feet at the dam.

The Mexico-Armstrong soil association is prevalent in the Vandalia City Reservoir watershed. These are poorly, to somewhat poorly drained claypan soils that have a high potential for runoff of pesticides and nutrients. Mexico soils were formed under tallgrass prairie and are located on ridge tops. Armstrong soils were formed under tallgrass prairie and woodland and are located on side slopes. Slow permeability of the subsoil causes these soils to become saturated early in the growing season and contributes to surface runoff. Other soils, such as Keswick and Goss, were formed in glacial till (clay, sand, gravel and boulders left behind when glaciers melt). These soils are found on upland side slopes. Nearly 21,000 tons of sediment is estimated to be lost from this 3,680-acre watershed annually, of which 4,700 tons are deposited within the reservoir (Vandalia Watershed Management Committee, 1999).

Karst features like caves, springs and sinkholes are rare in this area. The few springs in this region have a relatively low flow and are usually highly mineralized. Because the availability of usable groundwater in northern Missouri is so limited, drinking water reservoirs are a necessary component in the public water supply for urban and rural citizens.

C. Defining the Problem:

Atrazine is a systemic herbicide that blocks photosynthesis. It has been a major herbicide used for corn production since its introduction in 1958. Atrazine is the most heavily used herbicide in corn and grain sorghum production in Missouri, where it provides selective broadleaf control and grass suppression at a lower cost than many other herbicides. Watershed vulnerability to agrichemical contamination is based on the chemistry of the contaminant, hydrology of a region and land-use. Streams draining watersheds with runoff-prone soils, such as those existing in the Vandalia City Reservoir watershed, may periodically contain high herbicide levels.

Atrazine was thought to be a Group C carcinogen (i.e., possibly caused cancer in humans) when the department first placed Vandalia City Reservoir on the 1998, and subsequently the 2002, 303(d) list of impaired waters. It was listed for atrazine contamination. However, in the October 2003 *Interim Reregistration Eligibility Decision* (EPA IRED, 2003), the U.S. Environmental Protection Agency (EPA) stated it had no clear indication that atrazine caused cancer in humans. Various studies have also been conducted to assess the effects of atrazine on amphibians, especially focusing on whether or not it was associated with endocrine disruption and thus reproduction. In the October 2003 IRED, EPA stated that the data available at that time was insufficient to make a determination as to the potential for atrazine to impact reproduction in amphibians. EPA continues to review new studies on both issues as they become available.

Regardless of the research results reported subsequent to the 2002 listing, Missouri is still using the 2002 303(d) list, which is the currently approved list, so is writing the TMDL based on knowledge and guidance related to atrazine when it was listed in 2002.

"Drinking water supply" is identified as the designated beneficial use that is considered impaired. The "drinking water supply" use is defined as follows:

> "Maintenance of a raw water supply which will yield potable water after treatment by public water treatment facilities."*
>
> *Water Quality Standards, 10 CSR 20-7.031(1)(C)10., Page 11.

The impairment of this lake is based on exceedence of the specific criterion for atrazine in a drinking water supply (i.e., more than allowed), as listed in Missouri's Code of State Regulations at 10 CSR 20-7.031 (11/30/05), Table A- Criteria for Designated Uses, Pesticides. (Page 21. www.sos.mo.gov/adrules/csr/current/10Csr/10c20-7a.pdf). The 3 µg/L criterion for atrazine in surface waters is the same as the criterion used for drinking water (i.e., processed or "finished" water). However, compliance with the drinking water standard is measured as a running annual average and the surface water standard in Table A (for raw water) is based on a 70-year mean.

Although the department understands the desire for the TMDL to use the running annual average in its evaluation of trends, it is required to use a longer period to determine compliance with this particular standard. Therefore, the department must proceed with the TMDL based on the published standard (in Table A) for the drinking water supply use, which is 3 µg/L expressed as a 70-year mean. However, because we do not have a 70-year data set, the TMDL uses all of the data available since the last significant event (implementation of BMPs in response to watershed committee efforts beginning in 1998) in order to most closely match the criterion in the water quality standards.

D. Source Analysis:

There are no point source discharges for atrazine within the Vandalia City Reservoir watershed so the only sources of atrazine in the lake are linked to nonpoint sources. Potential mechanisms transporting this herbicide include overland water runoff, rainfall containing low levels of dust falling directly into the lake, and drainage tile discharge containing atrazine from infiltration. Some loss of atrazine from the field in the form of surface runoff typically occurs. Atrazine loss typically ranges from one to five percent depending on the tillage system, rain events and timing of application (Baker and Mickelson, 1994). Runoff of atrazine is due to atrazine's solubility in water, moderate adsorption to clay and other soil particles, and persistence in the environment with an average field half-life of 60 days (Ahrens, 1994). Kansas State researchers have found that 90 percent of atrazine loss occurs in the water portion of runoff and only 10 percent with the eroding soil particles (Devlin, et. al., 2000). Due to the nature of the predominant soil types in the watershed, atrazine gets to the lake from application sites via overland runoff. Detailed land use and watershed morphology information may be found in Appendices A and D, respectively.

3. Description of the Applicable Water Quality Standards and Numeric Water Quality Targets

A. Designated Beneficial Uses:
The designated uses of Vandalia City Reservoir, WBID 7032, are:

- Livestock and Wildlife Watering
- Protection of aquatic life (Limited warm-water fishery)
- Human health protection (Fish consumption)
- Secondary contact recreation (Note: The former "Boating and canoeing" use was revised and renamed in the Missouri Water Quality Standards effective January 2006.)
- Drinking water supply

The impaired use is drinking water supply.

B. Antidegradation Policy:
Missouri's Water Quality Standards include the Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after November 29, 1975, the date of EPA's first Water Quality Standards Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of designated outstanding national resources, such as waters of national and state parks and wildlife refuges and water of exceptional recreational or ecological significance and are listed in the rules at 10 CSR 20-7.031(7) and (8). There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality (with the exception of some limited activities that result in temporary and short-term changes in water quality).

C. Specific Criteria and Numeric Water Quality Target:
Missouri's water quality standard for protecting human health through drinking water supply use is three (3) μg/L of atrazine. In addition, Missouri rules at 10 CSR 20-7.031(4)(B)4 state, "Drinking water criteria, for substances which are rendered nontoxic by transformation processes in the surface water body, shall apply at water supply withdrawal points." This rule applies the water criteria at the water supply withdrawal points. The "withdrawal point" is the point where water is drawn out of a water body (in this case, Vandalia City Reservoir) prior to being transported to a

drinking water processing plant. Some substances may degrade or attenuate after they enter a water body. So, in the case of a drinking water supply lake, regardless of what the levels of the pollutant are elsewhere in the lake, the levels found at the withdrawal point are what is important when drinking water is the protected use.

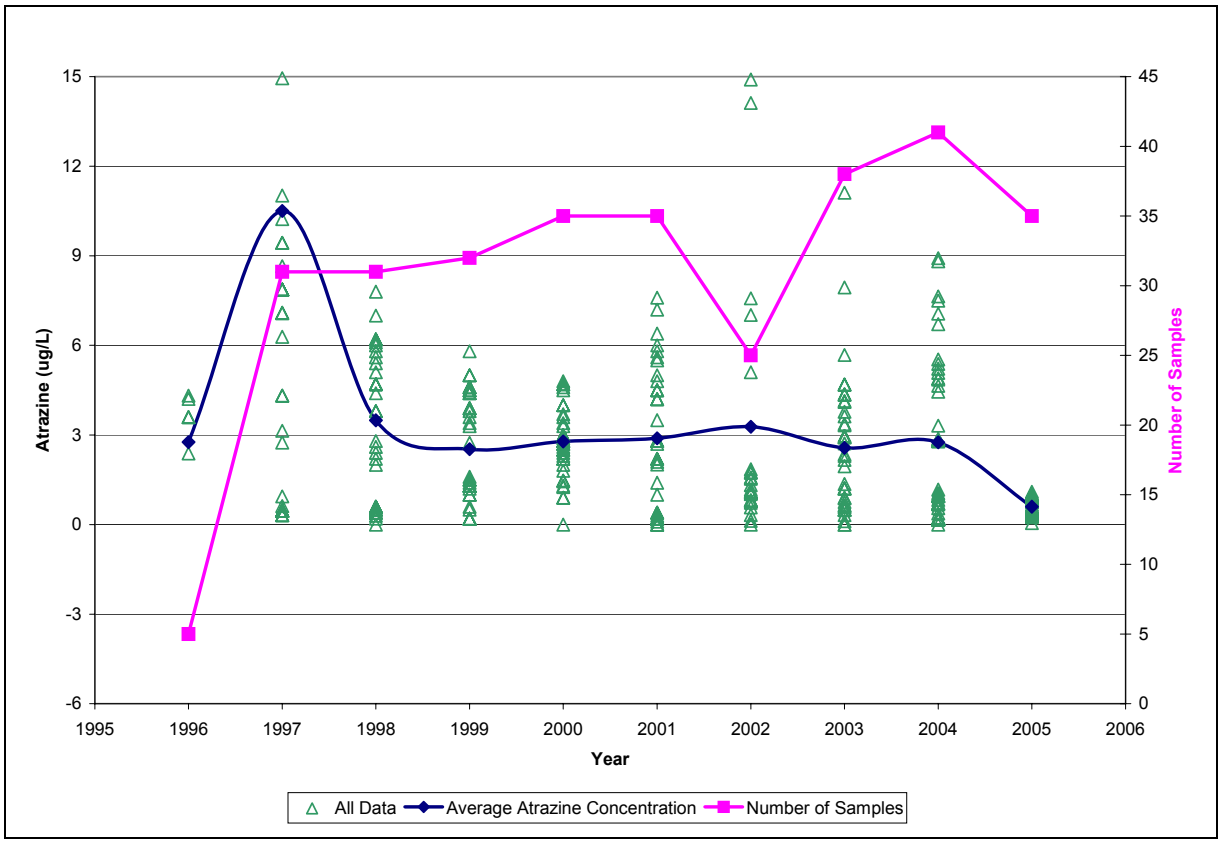
4. Modeling

A. Target:

The TMDL target corresponds to the standard atrazine concentration of three (3) µg/L at the withdrawal point. This is a raw water quality standard that should not be confused with the MCL in drinking water rules, although they share the same numerical value.

There are 308 atrazine records of data collected at the lake from October 10, 1996 to December 19, 2005 (Appendix B). These data represent raw water samples collected from the point where water is pulled from the reservoir for treatment (a fixed depth). Data values from 1997, taken before the implementation of best management practices (BMPs), were much higher than the rest of the years in record. The annual average atrazine concentration reached a maximum of 10.5 µg/L in 1997 (Figure 2).

Figure 2. Atrazine Concentration and Number of Samples (1996-2005).



Note: Atrazine data depicted within Figure 2 represent raw water concentrations within Vandalia City Reservoir (Also see Appendix B.). For better visualization, single concentration values greater than 15 µg/L are not shown in Figure 2.

Because of this data bias, only data collected after 1998, which corresponded to the adoption of BMPs in the watershed, are considered representative of current conditions and consequently used for this TMDL calculation.

B. Approach and Calculation of Load Capacity:
This TMDL is based on data analysis. A water body can only take (assimilate) so much pollution before negative impacts become evident. The assimilative capacity of the lake at any given time is a function of its water volume and atrazine concentration. Lake volume fluctuates throughout the year and depends on precipitation, withdrawal and evaporation.

Load Capacity (LC) is defined as the greatest amount of loading of a pollutant that a water body can receive (and assimilate) without violating water quality standards. This load is then divided among the point source (Waste Load Allocation, or WLA) and nonpoint source (Load Allocation, or LA) contributions of the pollutant to the water body, with an allowance for a Margin of Safety (MOS). If the Margin of Safety is *implicit*, no numeric allowance is necessary. In general, the TMDL or LC is expressed in the following manner:

$$TMDL = LC = WLA + LA + MOS$$

Note that these terms are explained in detail in the following sections.

C. Waste Load Allocation (Point Source Loads):
The Waste Load Allocation (WLA) is the proportion of a receiving water body's load capacity that is allocated to its existing or future point sources of pollution. In other words, it is the maximum allowable amount of the pollutant that can be assigned to (i.e., allowed to be discharged from) point sources. Because there are no point source discharges for atrazine within the Vandalia City Reservoir watershed, the waste load allocation established under this TMDL is zero.

D. Load Allocation (Nonpoint Source Loads):
All atrazine loads in the Vandalia City Reservoir watershed are attributed to runoff from agricultural fields. Thus, the TMDL is equal to the load allocation plus a margin of safety.

The loading capacity is considered the maximum long-term average mass within the reservoir that results in compliance with the water quality criterion. This long-term average mass is determined by converting the cumulative running average concentration since 1999 into mass terms using the reservoir volume. Future monitoring data will be added to the available data set (1999 to present) to determine the long-term average mass (load allocation). Therefore, compliance with this TMDL is effectively evaluated by comparing the long-term cumulative average (1999 to present) to the water quality criterion.

MEC-Water Resources, Inc. collected lake volume records over the periods of April 12, 2002 to Nov. 25, 2002, April 7, 2003 to Nov. 11, 2003, and April 6, 2004 to Oct. 4, 2004. The most frequently occurring lake volume over this time period is 310 acre-feet (382,379 m^3). This representative volume is used to calculate the load capacity. Appendix C, Vandalia City Reservoir Volume Assessment, provides a list of lake volume in cubic meters (m^3) and acre feet at given water levels (in feet below full pool). Appendix D shows the contour and depth of the lake.

From Jan. 11, 1999 to Dec. 19, 2005, various entities collected 241 atrazine samples. The arithmetic average of the samples is 2.46 μg/L, the average of their cumulative average[4] is 2.52 μg/L, the standard deviation of the cumulative averages is 0.47 μg/L and their upper limit of the 95 percent confidence interval is 2.58 μg/L. Stated differently, 95 times out of 100 the average of the true population of cumulative means is less than 2.58 micrograms per liter. The analysis compared the overall average concentration to the standard and considered the variability among cumulative averages.

The load allocation is the product of the standard concentration (3 μg/L) and representative lake volume[5].

$$LA = LC = ((3.0 \times 10^{-6} g/L) * (1 \times 10^{3} L/m^{3}))/ (453.6 g/lb) * 382{,}379 m^{3} = 2.52 lbs$$

The existing load is calculated based on the 95th percent confidence interval of the cumulative means of atrazine concentration of 2.58 μg/L. As an example, existing load at 3.5 feet below full pool (272,284 m^3) is calculated as follows:

$$\text{Existing load} = ((2.58 \times 10^{-6} g/L) * (1 \times 10^{3} L/m^{3}))/ (453.6 g/lb) * 272{,}284 m^{3} = 1.5 lbs.$$

Because

$$\text{Load Allocation} = ((3.0 \times 10^{-6} g/L) * (1 \times 10^{3} L/m^{3}))/ (453.6 g/lb) * 272{,}284 m^{3} = 1.8 lbs,$$

This calculation again demonstrates that the existing load as calculated with the cumulative long-term average atrazine concentration is below the reservoir's load allocation.

E. Margin of Safety:

A Margin of Safety (MOS) is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. It is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

(1) Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
(2) Implicit - Incorporate the MOS as part of the critical conditions for the waste load allocation and the load allocation calculations by making conservative assumptions in the analysis.

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[4] The cumulative average, Y of a variable X, is defined as:
Y (1) = X(1)
Y (2) = (X(1) + X(2))/2
Y (3) = (X(1) + X(2) + X(3))/3 and Y(n)=[(X(1) +X(2)+…+X(n)]/n
That is, the cumulative mean of an element in a variable is simply the mean of all points in the variable up to and including that element (see the National Institute of Standards and Technology Web site, specifically the Information Technology Laboratory's Statistical Engineering Division: http://www.itl.nist.gov/div898/index.html).

[5] Conversion from μg/L to lb/m^3:
10^{-6} g/L * 10^3 L/m^3 * lb/453.6 g = 0.0000022 lb/m^3

For this TMDL calculation, the Margin of Safety is expressed implicity. The MOS is *implicit* in terms of conservative analytical assumptions used in analyzing the data. For this pollutant (resulting from agricultural runoff), the Margin of Safety is conservative:

1.) It is based on samples taken after the implementation of BMPs which reflect the current conditions in the watershed. The effectiveness of the BMPs, as shown by the reduction of atrazine concentration after 1997 and the continuing decline to present (Figure 2), provides assurance of reducing atrazine delivery to the lake. These BMPs ensure attainment and maintenance of a 3 μg/L or less atrazine in the lake.
2.) While the maximum contaminant level (MCL) is based on annualized four quarterly samples (See EPA's Technical Factsheet on Atrazine at: www.epa.gov/OGWDW/dwh/t-soc/atrazine.html), the data used for this calculation contains more samples per year and covers seven consecutive years. Using many samples and data covering many years is statistically more representative of the true atrazine concentration in the lake than that recommended by EPA. In addition, the high number of data records will reduce any effects on data due to weather fluctuation, in particular, the timing and amount of rainfall during atrazine application. Therefore, the results of the calculations are robust and representative of the current condition. They may be predictive of future conditions assuming continued implementation of on-going BMPs, thus providing for an additional implicit Margin of Safety.

5. Seasonal Variation

Atrazine is normally applied in the watershed from May through early June when the probability of rain is high. Soon after a rainfall event, monitoring data (Appendix B) during these months show atrazine concentrations at the withdrawal point increase sharply. Atrazine concentrations at the withdrawal point increase throughout May and/or June, level out through July and August and then slowly decrease by dilution, degradation and outflow until the next application season. A three- or four-inch rain during any time outside the application season can produce an observable decline in the lake atrazine concentration. This occurs when high concentration water is displaced by water containing small amounts of the chemical, changing the overall concentration. While the concentration of atrazine at the withdrawal point may occasionally exceed the target, the lake is evaluated as a running annual average concentration. So as long as the average concentration meets the target concentration, the lake is considered to be in compliance with the TMDL.

6. Monitoring Plans for TMDLs Under the Phased Approach

Monitoring is a particularly important aspect of this phased TMDL since this is a reflective approach rather than prescriptive. It allows detection of any significant changes in water quality of the lake and can be used to assess the effectiveness of implemented land use management. Several entities including the department, the University of Missouri, Syngenta Crop Protection, Inc. (formerly known as Novartis), and MEC-Water Resources, Inc. (Appendix B) collected atrazine-related data from 1996-2005. The City of Vandalia Water Treatment Plant continues to take quarterly samples for monitoring of compliance with the Drinking Water Standards program. The department will use future data for use attainment decisions during development of biannual 303(d) lists.

The January 2003 IRED, and subsequent October revision (discussed earlier in this TMDL under "Defining the Problem") requires that the registrant (in this case, Syngenta) must perform intensive monitoring of drinking water systems that may be sensitive to atrazine. Additionally, Syngenta is conducting a specialized testing program to monitor both "raw" and "finished" drinking water for atrazine, and it's chloro-metabolites, during high use periods. If EPA's set limits are exceeded, atrazine use may be disallowed in the Vandalia watershed.

As with all of Missouri's TMDLs, if continuing monitoring reveals that water quality standards are not being met, the TMDL will be reopened and re-evaluated accordingly. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

7. Implementation

In 1997 and 1998, the annual mean averages of atrazine in the lake exceeded 3 µg/L, the water quality criterion for drinking water supplies. In response, the city worked with staff members representing both the University of Missouri Outreach & Extension Office and the Natural Resources Conservation Service (NRCS) to create the Vandalia Watershed Management Committee in 1997. The committee sprang from an initial meeting called by the city in order to inform the producers in the watershed about the problem and what the city had been doing to try to deal with it. The meeting sparked action by city staff and landowners into action to begin to take steps to address this situation. Committee members included representatives from:

- City of Vandalia,
- Vandalia elected officials,
- Vandalia residents,
- Landowners and producers within the reservoir watershed,
- Pike and Audrain County Soil and Water Conservation District (SWCD) members, and
- University of Missouri extension staff.

Personnel from the Missouri Corn Growers Association, Missouri Department of Natural Resources, Missouri Department of Conservation, Mark Twain Water Quality Initiative, the Missouri Department of Health and other agencies and businesses serve as resources to the committee. The group met monthly for approximately two years and then met quarterly for some time after that.

The committee subsequently developed an atrazine reduction plan that included farmers changing some of their management practices. In October 1999, the committee published that intent in a document entitled, *Vandalia City Reservoir Water Resources Management Plan*, where it listed committee goals as follows:

- Reduce contaminant levels in the public water supply,
- Write a management plan that educates and improves communication, volunteerism and cooperation,
- Create stewardship opportunities,
- Ensure acceptable water treatment costs,
- Monitor water quality, and
- Maintain water supply below MCL limits.

The committee held four meetings in the late 1990s specifically to engage landowners in the process.

In 1997, the Environmental Quality Incentive Program (EQIP) became available to producers in the watershed through NRCS. Farmers could sign up for this program and receive an incentive payment for using less than a pound per acre of atrazine and/or for using an alternative herbicide. They could participate in that program for five years. According to the Pike County SWCD, ten five-year contracts started in spring of 2000 and two more started in 2001. Half of the 12 contracts were for both nutrient and pest management, and half were for pest management alone. All of the aforementioned contracts will expire by the end of 2006.

According to NRCS policy, landowners are not allowed to sign up for pest management practices on the same acreage in subsequent EQIP contracts. Even so, landowners in the watershed are likely to adopt practices to ensure continued low levels of atrazine in the lake. They may or may not continue with the practice of using less than one pound per acre of atrazine, but they may lessen application rates, use split applications or establish buffer strips. They would do so beyond the life of the EQIP incentives because of their concern for community health, as well as their desire to continue to have the option of using atrazine in the watershed in the future (See Memorandum of Agreement referenced later in this section).

Two landowners in the Vandalia City Reservoir watershed enrolled in the Conservation Reserve Enhancement Program (CREP) on Oct. 1, 2001. Missouri CREP is a joint effort between the U.S. Department of Agriculture and the Department of Natural Resources, specifically the Soil and Water Conservation Program and the Public Drinking Water Branch of the Water Protection Program. The goals of CREP are to reduce the risk of pesticides, nutrients and sediment from farms entering streams and reservoirs that provide rural water supplies. To achieve this goal, landowners receive financial incentives to promote retirement of highly erodible and environmentally sensitive land in targeted watersheds. The two landowners in the Vandalia watershed signed a 15-year contract to convert cropland to grassland.

The implementation of the *Water Resources Management Plan*, and subsequent adoption of BMPs resulted in a dramatic reduction of atrazine levels in raw water from 1997 to 1999 (See Figure 2 and Appendix B). The adoption of voluntary BMPs achieved successful results using economically and socially acceptable practices and is clearly a model for other atrazine-contaminated lakes in the state. The yearly running average of atrazine in the lake has been equal to or below the 3 µg/L water quality criterion since 2000. Cumulative efforts to reduce the amount of atrazine being delivered to the lake in the past seven years have been successful. It is reasonable to assume that as long as current practices continue into the future, atrazine concentrations in the lake will remain low. Assuming existing BMP efforts will be continued, further load reduction requirements are not necessary at this time.

In the spring of 2004, EPA and the registrants of pesticide products containing atrazine signed into effect a Memorandum of Agreement (MOA). The goal of the MOA, in relation to this and other selected surface water bodies, was to reduce loading of atrazine and its chloro-metabolites to total chlorotriazine levels below the newly developed drinking water criteria on which EPA and the technical registrants agreed. If the drinking water standards are not met, the use of atrazine may be excluded within the applicable watersheds.

As part of the MOA, the registrants have initiated a monitoring program on surface water for selected community water systems. The MOA provides details regarding conditions under which atrazine may continue to be used as a contingency to EPA approving the re-licensing registration of these products. It constitutes an incentive for atrazine manufacturers, distributors, and users to cooperate in order to protect the Vandalia City Reservoir's designated use as a drinking water supply lake. Syngenta, in cooperation with the Missouri Corn Growers Association and other entities, continues to work with producers in exploring employment of BMPs that could have a positive impact on water quality in the lake.

8. Reasonable Assurances

In most cases, "reasonable assurance" in reference to TMDLs relates only to point sources. Technically speaking, reasonable assurances are required when nonpoint source load allocation (LA) is used to offset waste load allocation (WLA) reductions that are needed to meet water quality standards. Since there are no point source discharges for atrazine within the Vandalia City Reservoir watershed, reasonable assurances do not apply. As a result, any assurances that contributers of nonpoint pollution source atrazine will implement measures to reduce their contribution in the future, will not be found in this section. Instead, discussion of reduction efforts relating to nonpoint sources of atrazine can be found in section "7. Implementation" of this TMDL.

9. Public Participation

A. Local

The Vandalia Watershed Management Committee was established in the fall of 1997 to address concerns including, but not limited to, pesticide and animal manure runoff into Vandalia City Reservoir. As detailed earlier in section "7. Implementation" of this TMDL, the group consisted of city officials, city employees, farmers, state and federal agency staff and city residents. Goals and accomplishments of the committee are also detailed under "Implementation."

A hiatus followed the initial regularity of the committee meetings while landowners pursued the goals of the plan. The committee met again in February 2004, with the intent of updating the management plan, although this was not accomplished by the June 15, 2004 meeting. Since that time, personnel associated with the original plan changed, as did the department's assigned TMDL staff. The group did not meet again until April 10, 2006, when the new Chief Water Treatment Plant Operator organized a meeting with the goal of revitalizing the watershed group. The committee made plans to begin updating the existing watershed plan.

B. Department of Natural Resources

All draft TMDLs include a 30-day open public comment period as part of the Missouri Department of Natural Resources' public participation requirements. The public notice period for this draft Vandalia Lake TMDL was from June 2, 2006 to July 2, 2006. Groups who received the public notice announcement included:

- Missouri Clean Water Commission
- Vandalia Watershed Management Committee
- City of Vandalia
- Water Quality Coordinating Committee

- Missouri Department of Agriculture
- Syngenta Crop Protection, Inc.
- Environmental Resources Coalition
- MEC Water Resources, Inc.
- University of Missouri Outreach and Extension
- Pike County Soil and Water Conservation District
- Stream Team volunteers in the county
- appropriate state legislators

A copy of the draft TMDL and the associated public notice were posted in the Vandalia City Hall and the Vandalia Branch Library. In order to provide a more direct venue to receive public comments, the department held a public meeting in Vandalia on June 15, 2006. Also, the department posted the notice, the Vandalia City Reservoir TMDL Information Sheet (www.dnr.mo.gov/env/wpp/tmdl/info/vandalia-res-info.pdf) and the TMDL (www.dnr.mo.gov/env/wpp/tmdl/vandalia-lk-draft-tmdl.pdf) on its Web site, making them available to anyone with access to the Web. A copy of the notice, any comments received and the department's responses were placed in the Vandalia Lake TMDL file as detailed below.

10. Administrative Record and Supporting Documentation on File with the Department

An administrative record on the Vandalia Lake TMDL is kept on file with the Missouri Department of Natural Resources. It includes the following:

- Vandalia Lake TMDL;
- Vandalia City Reservoir Water Resources Management Plan. October 1999 (See citation);
- U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs. January, 2003. Interim Reregistration Eligibility Decision [IRED] for Atrazine, Case No. 0062;
- U.S. Environmental Protection Agency, Preregistration Branch 3, Health Effects Division, Office of Prevention, Pesticides and Toxic Substances. October 31, 2003. Revised Human Health Risk Assessment: Atrazine (for the Reregistration Eligibility Decision)[IRED];
- U.S. Environmental Protection Agency. Signed April 28, 2004 (by EPA) and May 17, 2004 (by registrant representative). Memorandum of Agreement Between the U.S. Environmental Protection Agency and Agan Chemical Manufacturing, Dow AgroSciences, Drexel Chemical, Oxon Italia S.P.A., and Syngenta Crop Protection Concerning the Registration of Pesticide Products Containing Atrazine. Associated with the above referenced January 2003 Atrazine IRED;
- Public Notice announcement;
- Vandalia Lake (a.k.a. Weldon H. "Pete" Steiner Reservoir) TMDL Information Sheet; and
- Public comments and the department's responses.

11. Appendices and Citations

Appendices:

Appendix A – 2000 Land use map for the Vandalia City Reservoir watershed
Appendix B – Data for Vandalia City Reservoir from 1996 through 2005

Appendix C – Vandalia City Reservoir Volume Assessment
Appendix D – Vandalia City Reservoir Contour Map

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Missouri Code of State Regulations (11/30/05), Water Quality Standards 10 CSR 20-7.031(1)(F). Classified Waters. Page 11. [See: http://www.sos.mo.gov/adrules/csr/current/10Csr/10c20-7a.pdf]

Missouri Code of State Regulations (11/30/05), Water Quality Standards 10 CSR 20-7.031(4) Specific Criteria, (B) Toxic Substances, 4. Drinking water criteria. Page 14. [See: http://www.sos.mo.gov/adrules/csr/current/10Csr/10c20-7a.pdf]

Missouri Code of State Regulations (11/30/05), Water Quality Standards 10 CSR 20-7.031, Table A- Criteria for Designated Uses, Pesticides. Page 21. [See: http://www.sos.mo.gov/adrules/csr/current/10Csr/10c20-7a.pdf]

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U.S. Environmental Protection Agency. Signed April 28, 2004 (by EPA) and May 17, 2004 (by registrant representative). Memorandum of Agreement Between the U.S. Environmental Protection Agency and Agan Chemical Manufacturing, Dow AgroSciences, Drexel Chemical, Oxon Italia S.P.A., and Syngenta Crop Protection Concerning the Registration of Pesticide Products Containing Atrazine. Associated with the above referenced January 2003 Atrazine IRED. http://www.epa.gov/oppsrrd1/reregistration/atrazine/ - See "Memorandum of Agreement" under "January 2003 Atrazine IRED."

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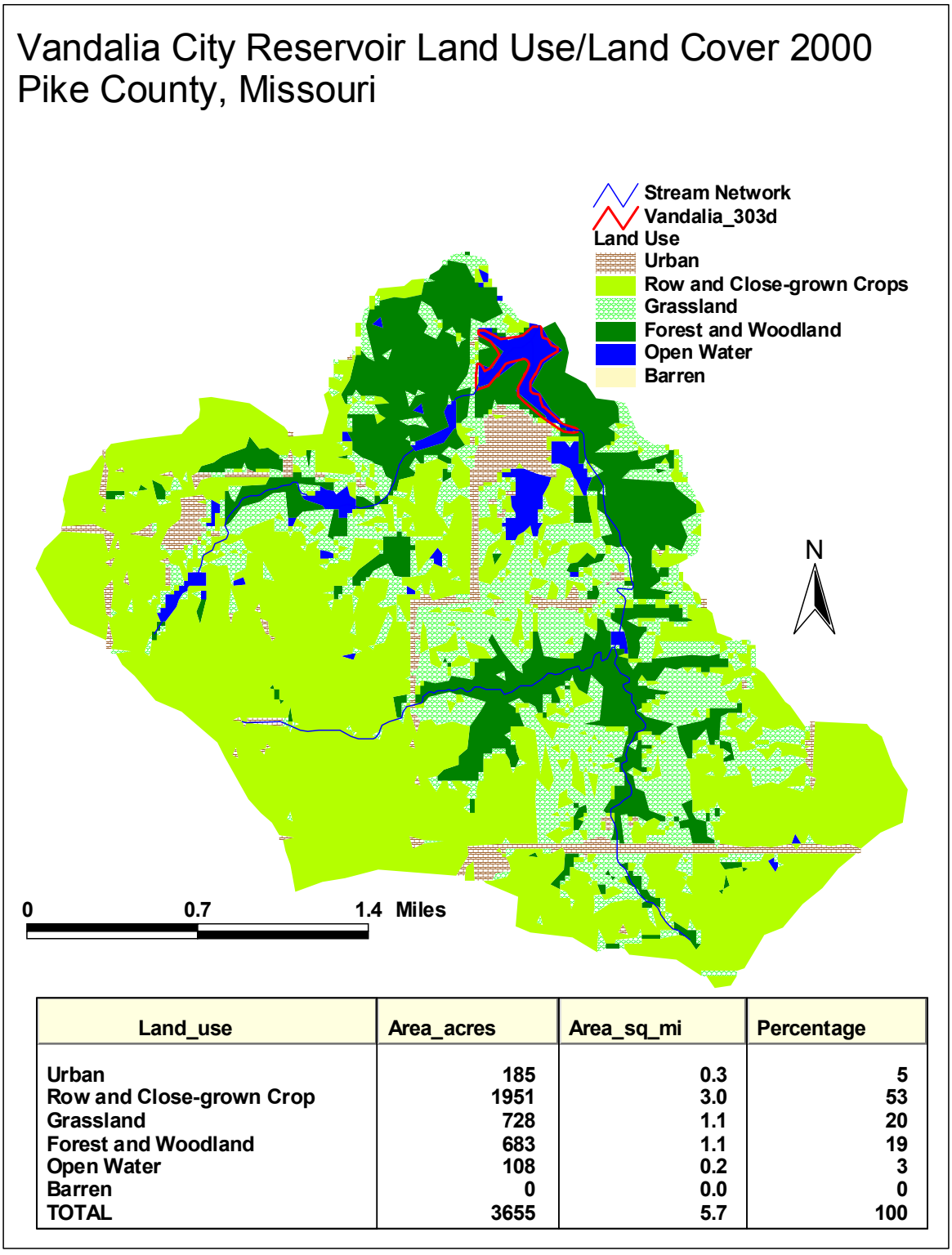
Appendix A.
Land Use Distribution in Vandalia City Reservoir Watershed (MoRAP)



Land_use	Area_acres	Area_sq_mi	Percentage
Urban	185	0.3	5
Row and Close-grown Crop	1951	3.0	53
Grassland	728	1.1	20
Forest and Woodland	683	1.1	19
Open Water	108	0.2	3
Barren	0	0.0	0
TOTAL	3655	5.7	100

Appendix B.
Raw Water Data from Vandalia City Reservoir, 1996-2005

SYNGENTA = Syngenta Crop Protection, Inc.
MDNR = Missouri Department of Natural Resources
MEC = MEC Water Resources, Inc.
(atrazine concentration in micrograms per liter)

Date	ORG	YR	MO	DAY	Atrazine (ug/L)
10/21/1996	Syngenta	1996	10	21	0
11/4/1996	Syngenta	1996	11	4	4.21
11/18/1996	Syngenta	1996	11	18	3.6
12/2/1996	Syngenta	1996	12	2	3.6
12/16/1996	Syngenta	1996	12	16	2.38
1/13/1997	Syngenta	1997	1	13	4.32
1/27/1997	Syngenta	1997	1	27	4.32
2/10/1997	Syngenta	1997	2	10	2.75
2/24/1997	Syngenta	1997	2	24	0.94
3/10/1997	Syngenta	1997	3	10	0.46
3/24/1997	Syngenta	1997	3	24	0.31
4/7/1997	Syngenta	1997	4	7	0.46
4/21/1997	Syngenta	1997	4	21	0.46
5/5/1997	Syngenta	1997	5	5	0.46
5/12/1997	Syngenta	1997	5	12	0.62
5/19/1997	Syngenta	1997	5	19	0.31
5/27/1997	Syngenta	1997	5	27	0.46
6/2/1997	Syngenta	1997	6	2	66.92
6/9/1997	Syngenta	1997	6	9	47.24
6/16/1997	Syngenta	1997	6	16	31.49
6/23/1997	Syngenta	1997	6	23	20.46
6/30/1997	Syngenta	1997	6	30	27.55
7/7/1997	Syngenta	1997	7	7	14.95
7/14/1997	Syngenta	1997	7	14	7.87
7/21/1997	Syngenta	1997	7	21	7.87
7/28/1997	Syngenta	1997	7	28	3.14
8/11/1997	Syngenta	1997	8	11	4.32
8/25/1997	Syngenta	1997	8	25	9.44
9/8/1997	Syngenta	1997	9	8	9.44
9/22/1997	Syngenta	1997	9	22	7.87
10/6/1997	Syngenta	1997	10	6	11.02
10/20/1997	Syngenta	1997	10	20	8.65
11/3/1997	Syngenta	1997	11	3	7.08
11/17/1997	Syngenta	1997	11	17	6.29
12/1/1997	Syngenta	1997	12	1	7.87
12/15/1997	Syngenta	1997	12	15	10.23
1/12/1998	Syngenta	1998	1	12	7.1
1/26/1998	Syngenta	1998	1	26	7
2/9/1998	Syngenta	1998	2	9	4.4
2/23/1998	Syngenta	1998	2	23	2
3/9/1998	Syngenta	1998	3	9	0

3/23/1998	Syngenta	1998	3	23	0.5
4/6/1998	Syngenta	1998	4	6	0.4
4/20/1998	Syngenta	1998	4	20	0.5
5/4/1998	Syngenta	1998	5	4	0.2
5/11/1998	Syngenta	1998	5	11	0.3
5/18/1998	Syngenta	1998	5	18	0.4
5/26/1998	Syngenta	1998	5	26	0.6
6/1/1998	Syngenta	1998	6	1	0.6
6/8/1998	Syngenta	1998	6	8	0.6
6/15/1998	Syngenta	1998	6	15	4.7
6/22/1998	Syngenta	1998	6	22	5.6
6/29/1998	Syngenta	1998	6	29	7.8
7/6/1998	Syngenta	1998	7	6	3.8
7/13/1998	Syngenta	1998	7	13	4.7
7/20/1998	Syngenta	1998	7	20	6.1
7/27/1998	Syngenta	1998	7	27	6
8/10/1998	Syngenta	1998	8	10	6.2
8/24/1998	Syngenta	1998	8	24	5.8
9/8/1998	Syngenta	1998	9	8	3.8
9/21/1998	Syngenta	1998	9	21	5.1
10/5/1998	Syngenta	1998	10	5	4.7
10/19/1998	Syngenta	1998	10	19	5.4
11/2/1998	Syngenta	1998	11	2	6.2
11/16/1998	Syngenta	1998	11	16	2.6
11/30/1998	Syngenta	1998	11	30	2.4
12/14/1998	Syngenta	1998	12	14	2.8
1/11/1999	Syngenta	1999	1	11	2.2
1/25/1999	Syngenta	1999	1	25	1.2
2/8/1999	Syngenta	1999	2	8	0.2
2/22/1999	Syngenta	1999	2	22	0.5
3/8/1999	Syngenta	1999	3	8	0.2
3/22/1999	Syngenta	1999	3	22	0.2
4/5/1999	Syngenta	1999	4	5	0.2
4/19/1999	Syngenta	1999	4	19	1
5/3/1999	Syngenta	1999	5	3	1.5
5/10/1999	Syngenta	1999	5	10	1.3
5/17/1999	Syngenta	1999	5	17	1.3
5/24/1999	Syngenta	1999	5	24	1.3
6/1/1999	Syngenta	1999	6	1	1.5
6/7/1999	Syngenta	1999	6	7	1.4
6/14/1999	Syngenta	1999	6	14	1.6
6/21/1999	Syngenta	1999	6	21	0.6
6/28/1999	Syngenta	1999	6	28	1
7/6/1999	Syngenta	1999	7	6	5
7/12/1999	Syngenta	1999	7	12	4.5
7/19/1999	Syngenta	1999	7	19	4.6
7/26/1999	Syngenta	1999	7	26	3.9
8/9/1999	Syngenta	1999	8	9	4.4
8/23/1999	Syngenta	1999	8	23	5.8
9/7/1999	Syngenta	1999	9	7	5
9/20/1999	Syngenta	1999	9	20	4.4

10/4/1999	Syngenta	1999	10	4	3.6
10/18/1999	Syngenta	1999	10	18	3.9
11/1/1999	Syngenta	1999	11	1	3.4
11/15/1999	Syngenta	1999	11	15	4.5
11/29/1999	Syngenta	1999	11	29	3.3
11/30/1999	MDNR	1999	12		2.74
12/13/1999	Syngenta	1999	12	13	4.6
1/10/2000	Syngenta	2000	1	10	3.8
1/24/2000	Syngenta	2000	1	24	3
2/7/2000	Syngenta	2000	2	7	2.8
2/21/2000	Syngenta	2000	2	21	4
2/29/2000	MDNR	2000	3		1.26
3/6/2000	Syngenta	2000	3	6	3.6
3/20/2000	Syngenta	2000	3	20	3
4/3/2000	Syngenta	2000	4	3	0.9
4/17/2000	Syngenta	2000	4	17	2.3
5/1/2000	Syngenta	2000	5	1	3.7
5/8/2000	Syngenta	2000	5	8	1.8
5/15/2000	Syngenta	2000	5	15	1.3
5/22/2000	Syngenta	2000	5	22	2.8
5/30/2000	Syngenta	2000	5	30	2.6
5/31/2000	MDNR	2000	6		1.48
6/5/2000	Syngenta	2000	6	5	2.7
6/12/2000	Syngenta	2000	6	12	3.3
6/19/2000	Syngenta	2000	6	19	0
6/26/2000	Syngenta	2000	6	26	4.7
7/10/2000	Syngenta	2000	7	10	2.8
7/17/2000	Syngenta	2000	7	17	4.7
7/24/2000	Syngenta	2000	7	24	4.8
7/31/2000	Syngenta	2000	7	31	4
8/7/2000	Syngenta	2000	8	7	4.6
8/21/2000	Syngenta	2000	8	21	4.5
8/31/2000	MDNR	2000	9		1.45
9/5/2000	Syngenta	2000	9	5	3.4
9/18/2000	Syngenta	2000	9	18	2
10/2/2000	Syngenta	2000	10	2	2.5
10/16/2000	Syngenta	2000	10	16	2.5
10/30/2000	Syngenta	2000	10	30	2.9
11/13/2000	Syngenta	2000	11	13	2.4
11/27/2000	Syngenta	2000	11	27	2.2
11/30/2000	MDNR	2000	12		0.9
12/11/2000	Syngenta	2000	12	11	2.7
1/8/2001	Syngenta	2001	1	8	2.2
1/22/2001	Syngenta	2001	1	22	2.1
2/12/2001	Syngenta	2001	2	12	0.4
2/26/2001	Syngenta	2001	2	26	0.1
2/28/2001	MDNR	2001	3		0
3/12/2001	Syngenta	2001	3	12	0.2
3/26/2001	Syngenta	2001	3	26	0.2
4/9/2001	Syngenta	2001	4	9	0.2
4/23/2001	Syngenta	2001	4	23	0.2

5/7/2001	Syngenta	2001	5	7	0.2
5/14/2001	Syngenta	2001	5	14	0.4
5/21/2001	Syngenta	2001	5	21	0.3
5/29/2001	Syngenta	2001	5	29	4.2
5/31/2001	MDNR	2001	6		1
6/4/2001	Syngenta	2001	6	4	5.6
6/11/2001	Syngenta	2001	6	11	7.6
6/18/2001	Syngenta	2001	6	18	6.4
6/25/2001	Syngenta	2001	6	25	7.2
7/2/2001	Syngenta	2001	7	2	6
7/9/2001	Syngenta	2001	7	9	5.5
7/16/2001	Syngenta	2001	7	16	5
7/23/2001	Syngenta	2001	7	23	5.8
7/30/2001	Syngenta	2001	7	30	1.4
8/6/2001	Syngenta	2001	8	6	4.2
8/20/2001	Syngenta	2001	8	20	4.8
8/31/2001	MDNR	2001	9		2.81
9/4/2001	Syngenta	2001	9	4	4.5
9/17/2001	Syngenta	2001	9	17	4.5
10/1/2001	Syngenta	2001	10	1	3.5
10/15/2001	Syngenta	2001	10	15	2.8
10/29/2001	Syngenta	2001	10	29	2.8
11/12/2001	Syngenta	2001	11	12	2.7
11/26/2001	Syngenta	2001	11	26	2.2
11/30/2001	MDNR	2001	12		2.01
12/10/2001	Syngenta	2001	12	10	2.2
2/28/2002	MDNR	2002	3		0
3/5/2002	Syngenta	2002	3	5	0.58
4/8/2002	Syngenta	2002	4	8	0.32
4/21/2002	MEC	2002	4	21	0.725
4/23/2002	Syngenta	2002	4	23	1.17
5/6/2002	Syngenta	2002	5	6	1.73
5/15/2002	MEC	2002	5	15	1.02
5/20/2002	Syngenta	2002	5	20	0.79
5/31/2002	MDNR	2002	6		7.58
6/3/2002	Syngenta	2002	6	3	0.82
6/4/2002	MEC	2002	6	4	0.79
6/17/2002	Syngenta	2002	6	17	14.12
6/25/2002	MEC	2002	6	25	15.05
7/8/2002	Syngenta	2002	7	8	14.91
7/22/2002	Syngenta	2002	7	22	5.10
7/30/2002	MEC	2002	7	30	7.02
8/5/2002	Syngenta	2002	8	5	0.13
8/28/2002	MEC	2002	8	28	1.06
8/31/2002	MDNR	2002	9		1.09
9/9/2002	Syngenta	2002	9	9	1.10
9/25/2002	MEC	2002	9	25	1.85
10/7/2002	Syngenta	2002	10	7	1.76
11/4/2002	Syngenta	2002	11	4	1.54
11/30/2002	MDNR	2002	12		0.00
12/9/2002	Syngenta	2002	12	9	1.58

1/13/2003	Syngenta	2003	1	13	1.32
2/10/2003	Syngenta	2003	2	10	1.20
2/28/2003	MDNR	2003	3		0.00
3/10/2003	Syngenta	2003	3	10	0.58
4/7/2003	MEC	2003	4	7	0.32
4/14/2003	Syngenta	2003	4	14	0.65
4/30/2003	MEC	2003	4	30	0.62
5/12/2003	Syngenta	2003	5	12	1.22
5/20/2003	MEC	2003	5	20	0.48
5/21/2003	Syngenta	2003	5	21	0.91
5/27/2003	Syngenta	2003	5	27	0.88
5/31/2003	MDNR	2003	6		2.17
6/2/2003	Syngenta	2003	6	2	0.11
6/4/2003	MEC	2003	6	4	0.50
6/9/2003	Syngenta	2003	6	9	0.76
6/16/2003	Syngenta	2003	6	16	11.11
6/18/2003	MEC	2003	6	18	4.15
6/23/2003	Syngenta	2003	6	23	7.94
6/30/2003	Syngenta	2003	6	30	5.68
7/7/2003	Syngenta	2003	7	7	4.70
7/14/2003	Syngenta	2003	7	14	4.37
7/15/2003	MEC	2003	7	15	4.34
7/21/2003	Syngenta	2003	7	21	4.68
7/28/2003	Syngenta	2003	7	28	3.78
7/31/2003	MEC	2003	7	31	4.10
8/4/2003	Syngenta	2003	8	4	3.63
8/18/2003	Syngenta	2003	8	18	2.93
8/31/2003	MDNR	2003	9		1.20
9/8/2003	Syngenta	2003	9	8	2.97
9/9/2003	MEC	2003	9	9	3.33
9/22/2003	Syngenta	2003	9	22	2.92
10/6/2003	Syngenta	2003	10	6	3.37
10/20/2003	Syngenta	2003	10	20	2.30
11/3/2003	Syngenta	2003	11	3	2.35
11/17/2003	Syngenta	2003	11	17	2.72
11/30/2003	MDNR	2003	12		0.00
12/1/2003	Syngenta	2003	12	1	1.95
12/15/2003	Syngenta	2003	12	15	1.36
1/12/2004	Syngenta	2004	1	12	0.50
1/27/2004	Syngenta	2004	1	27	0.71
2/9/2004	Syngenta	2004	2	9	0.55
2/23/2004	Syngenta	2004	2	23	0.83
2/29/2004	MDNR	2004	3		0.00
3/8/2004	Syngenta	2004	3	8	0.37
3/22/2004	Syngenta	2004	3	22	0.21
4/5/2004	Syngenta	2004	4	5	0.21
4/6/2004	MEC	2004	4	6	0.16
4/12/2004	Syngenta	2004	4	12	0.18
4/19/2004	Syngenta	2004	4	19	0.22
4/26/2004	Syngenta	2004	4	26	0.19
4/27/2004	MEC	2004	4	27	0.16

5/3/2004	Syngenta	2004	5	3	0.19
5/10/2004	Syngenta	2004	5	10	0.20
5/17/2004	Syngenta	2004	5	17	0.68
5/18/2004	MEC	2004	5	18	0.96
5/24/2004	Syngenta	2004	5	24	1.17
6/1/2004	Syngenta	2004	6	1	3.31
6/7/2004	MEC	2004	6	7	8.81
6/7/2004	Syngenta	2004	6	7	5.38
6/15/2004	Syngenta	2004	6	15	5.53
6/21/2004	Syngenta	2004	6	21	7.50
6/28/2004	Syngenta	2004	6	28	7.64
6/29/2004	MEC	2004	6	29	7.06
7/6/2004	Syngenta	2004	7	6	5.22
7/12/2004	Syngenta	2004	7	12	4.90
7/19/2004	Syngenta	2004	7	19	4.86
7/21/2004	MEC	2004	7	21	6.71
7/26/2004	Syngenta	2004	7	26	8.92
8/9/2004	Syngenta	2004	8	9	5.08
8/16/2004	MEC	2004	8	16	4.65
8/23/2004	Syngenta	2004	8	23	4.45
9/7/2004	Syngenta	2004	9	7	2.80
9/20/2004	Syngenta	2004	9	20	2.87
10/4/2004	Syngenta	2004	10	4	2.78
10/18/2004	Syngenta	2004	10	18	2.84
11/8/2004	Syngenta	2004	11	8	0.95
11/22/2004	Syngenta	2004	11	22	0.98
12/6/2004	Syngenta	2004	12	6	1.05
12/20/2004	Syngenta	2004	12	20	0.96
01/03/05	Syngenta	2005	1	3	0.71
01/19/05	Syngenta	2005	1	19	0.45
01/31/05	Syngenta	2005	1	31	0.49
02/14/05	Syngenta	2005	2	14	0.30
02/28/05	Syngenta	2005	2	28	0.38
03/15/05	Syngenta	2005	3	15	0.61
03/28/05	Syngenta	2005	3	28	0.24
04/04/05	Syngenta	2005	4	4	0.46
04/11/05	Syngenta	2005	4	11	0.51
04/18/05	Syngenta	2005	4	18	0.39
04/25/05	Syngenta	2005	4	25	0.43
05/02/05	Syngenta	2005	5	2	0.05
05/09/05	Syngenta	2005	5	9	0.56
05/16/05	Syngenta	2005	5	16	0.43
05/23/05	Syngenta	2005	5	23	0.35
05/31/05	Syngenta	2005	5	31	1.03
06/06/05	Syngenta	2005	6	6	0.95
06/13/05	Syngenta	2005	6	13	0.83
06/20/05	Syngenta	2005	6	20	0.99
06/27/05	Syngenta	2005	6	27	0.76
07/05/05	Syngenta	2005	7	5	0.79
07/11/05	Syngenta	2005	7	11	0.86
07/18/05	Syngenta	2005	7	18	0.94

07/25/05	Syngenta	2005	7	25	0.89
08/01/05	Syngenta	2005	8	1	1.10
08/15/05	Syngenta	2005	8	15	0.78
08/29/05	Syngenta	2005	8	29	0.89
09/12/05	Syngenta	2005	9	12	0.67
09/26/05	Syngenta	2005	9	26	0.75
10/11/05	Syngenta	2005	10	11	0.56
10/24/05	Syngenta	2005	10	24	0.31
11/07/05	Syngenta	2005	11	7	0.32
11/21/05	Syngenta	2005	11	21	0.43
12/05/05	Syngenta	2005	12	5	0.35
12/19/05	Syngenta	2005	12	19	0.35

Appendix C.
Vandalia City Reservoir Volume Assessment

Water Level (Feet Below Full Pool)	Lake Volume (m^3)	Lake Volume (Acre Feet)
0.0	388,337	315
0.5	370,492	300
1.0	353,145	286
1.5	336,223	272
2.0	319,690	259
2.5	303,516	246
3.0	287,699	233
3.5	272,248	221
4.0	257,173	208
4.5	242,496	196
5.0	228,221	185
5.5	214,345	174
6.0	200,842	163
6.5	187,750	152
7.0	175,076	142

Appendix D.
Vandalia City Reservoir Contour Map